APPENDIX M
STREAM CHANNELIZATION AND ENCROACHMENT

Prepared by Lolo National Forest

Introduction

Two railroad grades, a local highway, and Interstate 90 confine the St. Regis River along both sides. Construction of these transportation facilities over the last 100 years has established the valley bottom of the St. Regis watershed as a major transportation corridor. The development of the transportation corridor began with the building of a military road between Fort Walla Walla in Washington and Fort Benton in Montana. In his 1863 report, Captain John Mullan chronicles the reconnaissance and construction effort he led to establish this route (Mullan 1863). The historic Mullan Trail today exists in remnant sections in Mullan Creek, East Fork of Twelvemile Creek, and the St. Regis valley bottom and low hillslopes up to Lookout Pass and is not affecting encroachment and channelization of the St. Regis River.

The presence of the Mullan Trail through the St. Regis watershed set the stage for additional transportation routes to follow. The Milwaukee Railroad, also known as the Route of the Hiawatha, was opened in 1909. In the St. Regis watershed, the Milwaukee is located on the south side of the St. Regis River from the town of St. Regis, extending up the watershed low on the southern valley wall and valley bottom, and eventually leaving its proximity to the St. Regis River near Saltese, climbing up to the St. Paul Tunnel from Taft along Rainy Creek. The old Northern Pacific Railroad grade extends up the valley on the north side of the river. At the Taft exit, the old Northern Pacific grade remains close to the river, and continues up the drainage, crossing the mountains near Lookout Pass. Remnant segments of old State Highway 10 can be found adjacent to the St. Regis River. Conversion of State Highway 10 into Interstate Highway 90 began in the 1960's, and was completed in the1980's. All major tributaries to the St. Regis River also contain at least one road up their respective valley bottoms.

The development of the St. Regis valley as a major transportation corridor has resulted in shortening, straightening, and overall channelization of the river, loss of floodplain, and destruction of most of the riparian area. Low sinuosity, riffle dominated reaches, and lack of fish habitat quality, quantity, and variety characterize the St. Regis River. Transportation facilities have cut off stream meanders, removed large woody debris, and eliminated large woody debris recruitment resulting in a lack of high quality pools for fish habitat (Hendrickson 2000). Channelization has disconnected the river from its meanders and floodplain, eliminating renewal of the riparian area and the energy dissipating function of the meanders and floodplain. As a result, increased water velocities have caused incision of the stream channel and increased the transport capacity of the stream, increasing the channel substrate particle size. Bank armoring in the form of riprap has been installed along the banks for much of the river length to protect the transportation facilities from the increased velocities of the confined stream.

Three methods were used to quantify the length of stream encroached, length of banks riprapped, and/or length of channel otherwise altered within the Lolo National Forest boundary. These methods include GIS spatial analysis, air photo interpretation, and field measurements.

Methods

GIS Analysis – Roads & Streams
The 2000 Bull Trout baseline Section 7 Consultation study (Hendrickson 2000) examined road-watershed and road-stream relationships by HUC 6 using spatial analysis of GIS data including road and stream layers. Among the parameters evaluated was road density (length of road per area of land). Road density provides a metric for the degree of “roadedness” or development in a watershed. Watersheds with a greater road density have decreased capability of supporting strong populations of key salmonids (USDA Forest Service 1996). Road density for the St. Regis River watershed and its tributary watersheds were evaluated.

Among the other parameters evaluated by Hendrickson, 2000 was the length of stream with roads within 300’ and 125’. Roads within these stream buffers impact sediment delivery potential and large woody debris recruitment potential.

The 300’ buffer was used based on a review of a large body of research on sediment delivery distances (Belt, et al. 1992). The review concluded that sediment within 300’ of a water body has the potential to be delivered to the water body despite the presence of vegetation buffers. Roads are a source of sediment, and when constructed in riparian areas their proximity to a water body increases the likelihood of that sediment being delivered to the water body. Additionally, roads within 300’ of a stream generally hinder the attainment of the INFISH Riparian Management Objective, RMO, which partially delineates the Riparian Habitat Conservation Area (RHCA) with a 300’ buffer from perennial, fish-bearing streams (USDA Forest Service1995).

The 125’ buffer was used based on the average maximum height of the tree species most commonly found in riparian areas on the Lolo National Forest. Potential large woody debris recruitment is considered in terms of site potential tree height. In the region of the Lolo National Forest, mature trees within 125’ of a stream have the potential of falling into the stream, and thus being recruited as large woody debris. Roads within 125’ of streams preclude the growth of trees within the road template (often from top of cut slope to toe of the fill slope), decreasing the density of trees in the riparian area, and thus precluding the number of trees available for large woody debris recruitment.

GIS Analysis – Canopy Cover & Stream Shading
Stream shading and temperature are affected similarly. As roads preclude tree growth and reduce tree density in riparian areas, the ability of the riparian area to shade the stream and buffer stream temperature changes is also diminished. Percent canopy cover estimates were derived from satellite imagery using GIS spatial analysis. Percent canopy cover was broken out into classes: not mapped, low (20-40% cover), moderate (40-70% cover), and high (70-100% cover). Length of bank (including both right and left banks separately) in each canopy cover class was summarized for the St. Regis mainstem and many of its tributaries.

Air Photo Interpretation
Channel alterations and bank riprap were inventoried using year 2000, 1:15,840 scale color aerial photos. Length of apparent channel alterations and of apparent bank riprap was measured using a

digital planimeter. Observations were made for the mainstems of tributaries to the St. Regis River, mostly in the low valley bottoms where canopy cover and topography allow for visual inspection of these parameters from an aerial view at this scale. Observation of channel alteration and riprap in the mid- and upper-elevation valley bottoms is not possible from aerial photos due to dense canopy cover and valley walls. Length of stream bank armored with riprap, and length of altered stream channel were summarized by HUC 6 tributary.

Field Measurements

Field measurements were taken in 2002 to compare the channel bed elevations of the existing St. Regis River and adjacent cut off meanders. A Spectra Precision Laserplane Leveling System was used to acquire relative elevation measurements at three sites near Lolo National Forest stream survey site # 11 above Saltese. Elevation differences between the current channel of the St. Regis River and adjacent cutoff meanders were also collected in this vicinity as part of a relocation and restoration feasibility study which was contracted to a consulting firm by the Lolo National Forest in 1996 (Land & Water Consulting, Inc. 1996). Measured elevation differences from these two studies suggest the degree of incision that has occurred as a result of channel straightening, loss of channel length, and loss of ability to dissipate energy.

Results

GIS Analysis – Roads & Streams

The USDA Forest Service classified road density in examining the characteristics of aquatic/riparian ecosystems in the Columbia River Basin (CRB) (1996, **Table M-1**). Watersheds with greater than 4.7 mi/mi^2 have an "Extremely High" road density. "Very Low" road density is defined by 0.02 to 0.1 mi/mi^2.

The CRB study found that, as road density in a watershed increases, the ability of the watershed to support strong populations of key salmonids is diminished. The effect is more pronounced when all land management types are considered, and less pronounced when only National Forest lands are considered. For all lands, about 8% of watersheds with "High" road density supported strong salmonids populations, whereas, for National Forest lands, 22% of watersheds with "High" road density supported strong salmonids populations (**Figure M-1**).

GIS analysis of road density by HUC 6 (Hendrickson 2000) reveals 90% of the St. Regis watershed has a "High" road density. Only the Savenac Creek HUC 6 has a road density below the "High" classification, with a density of 1.1 mi/mi^2, "Moderate**,"** although most roads in Savenac Creek are concentrated in the lower third of the watershed, while the upper two-thirds are unroaded. Packer Creek is borderline "Moderate-High" with a road density of 1.7 mi/mi^2. Total road density for the entire St. Regis watershed is 2.8 mi/mi^2, "High**."**

Table M-1. Road density classification (USDA Forest Service, 1996)

Classification	Road Density (mi/mi^2)
Extremely High	> 4.7
High	1.7 - 4.7
Moderate	0.7 - 1.7
Low	0.1 - 0.7
Very Low	0.02 - 0.1

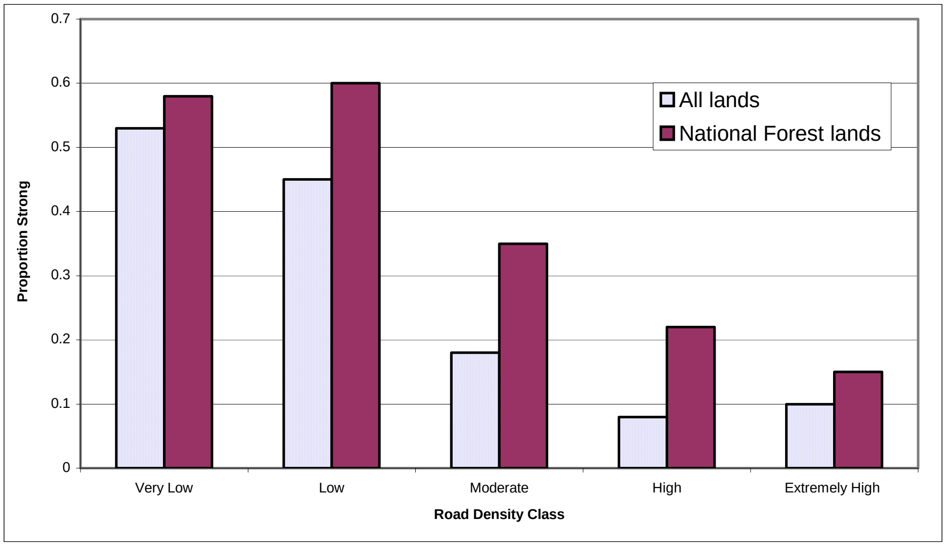

Figure M-1. Relationship between road density and watershed ability to support strong populations of key salmonids (adapted from USDA Forest Service, 1996)

Stream density (length of stream/area of land) was calculated using Hendrickson's results (2000). When comparing stream density to road density, all HUC 6 watersheds, except Savenac and Packer, have more length of road per square mile than length of stream (**Table M-2**).

Another way to examine stream or road density is to calculate and compare the average distance (Ad) between streams and between roads using the equation: **Ad = ½ (1/D)**, where D is density, the length of stream or road/area of land. In Twomile Creek, for example, where Ds (stream density) is 2.3 mi/mi^2, Ad between streams (Ads) is 0.217 miles, and where Dr (road density) is 3.9 mi/mi^2, Ad between roads (Adr) is 0.128 miles:

Ads	= ½ (1/2.3)	Adr	= ½ (1/3.9)
	= ½ (0.435)		= ½ (0.256)
	= 0.217		= 0.128

This means that on average, a raindrop falling on the ground (assuming overland flow conditions) has almost twice as far to travel to get to a stream (1146 feet) as to a road (677 feet).

Research shows that roads interact with surface and subsurface flow of water over hillslopes. This interaction may affect the hydrologic response of a watershed, including the timing and magnitude of the hydrograph. Wemple and Jones (2003) found that depending on the nature of storm events, watershed characteristics, and road segment attributes, storm flow response may be more rapid and have greater peaks because of the interaction roads have on hillslope flow.

Analysis of stream length encroached upon by roads within 300' and 125' shows that 33% of stream lengths in the St. Regis Watershed are encroached by roads within 300' of those streams, and 15% are encroached by roads within 125'. Nine out of twelve of the HUC 6 tributary watersheds to the St. Regis have greater than 30% of their streams' length encroached upon by

roads within 300'. Packer and Savenac Creeks have the least length of stream encroached by roads within 300', 26.2% and 15.2% respectively. Twin Creek is also relatively low (<30%) with 26.9% and 13.5% for 300' and 125' buffers respectively.

Table M-2 Road-stream and road-watershed relationships characterized in Bull Trout baseline Section 7 Consultation study (Hendrickson 2000). (Table adapted from Hendrickson, 2000).

HUC 6 No.	HUC Name	Area (miles^2)	Stream Length (miles)	Road Density (miles/ mile^2)	% Stream with Road w/in 300' of Stream	% Stream with Road w/in 125'	*Stream density
10	Twomile Cr	17.2	39.3	3.9	32.0	9.5	2.3
12	Lower St. Regis_Mullan +	38.3	100.1	3.6	37.3	19.8	2.6
9	Ward Cr	22.8	36.4	3.6	31.9	12.5	1.6
8	Twelvemile Cr +	59.8	157.6	3.4	34.0	15.6	2.6
7	Twin Cr_St Regis	20.0	45.0	2.9	26.9	13.5	2.3
1	Upper St. Regis +	41.5	81.2	2.8	37.8	20.6	2.0
3	Silver_Timber	30.5	65.4	2.5	30.7	14.6	2.2
11	Little Joe Cr +	43.4	103.5	2.5	36.8	18.9	2.4
4	Big Cr +	37.9	61.6	2.5	36.6	12.8	1.6
6	Deer Cr (St. Regis)	16.7	27.5	2.2	35.2	9.7	1.6
2	Packer Cr	18.2	40.8	1.7	26.2	10.6	2.2
5	Savenac Cr	16.6	41.9	1.1	15.2	6.3	2.5
	Total	363.0	800.0	2.8	265.4	122.1	

*Not part of Hendrickson, 2000 analysis. + On 2002 303(d) list.

Road density alone is not a good indicator of stream condition. Ward Creek and Twomile Creek have very high road densities, but fully support beneficial uses (Montana DEQ 2002). The percent stream length with road within 125' seems to be a better indicator of stream condition. All of the impaired streams, except Big Creek, have greater than 15% of stream length within 125'. However, only the mainstem of Big Creek is listed as impaired. Considering just this segment, greater than 15% of Big Creek mainstem is within 125' of road.

GIS Analysis – Canopy Cover & Stream Shading

Canopy cover analysis reveals that in general stream segments on the 2002 303(d) list have the lowest proportion of the "High" percent canopy cover class. These segments with less than 25% of stream length under High percent canopy cover include: Twelvemile, East Fork Big Creek, Big Creek mainstem, Little Joe mainstem, North Fork Little Joe, and St. Regis River. All of these tributaries, except East Fork Big Creek are on the 2002 303 (d) list. Of the stream segments not on the 303(d) list, the proportion of stream with High percent canopy cover class ranges from 31% for West Fork Big Creek to 64% for Deer Creek (**Figure M-2, Table M-3**).

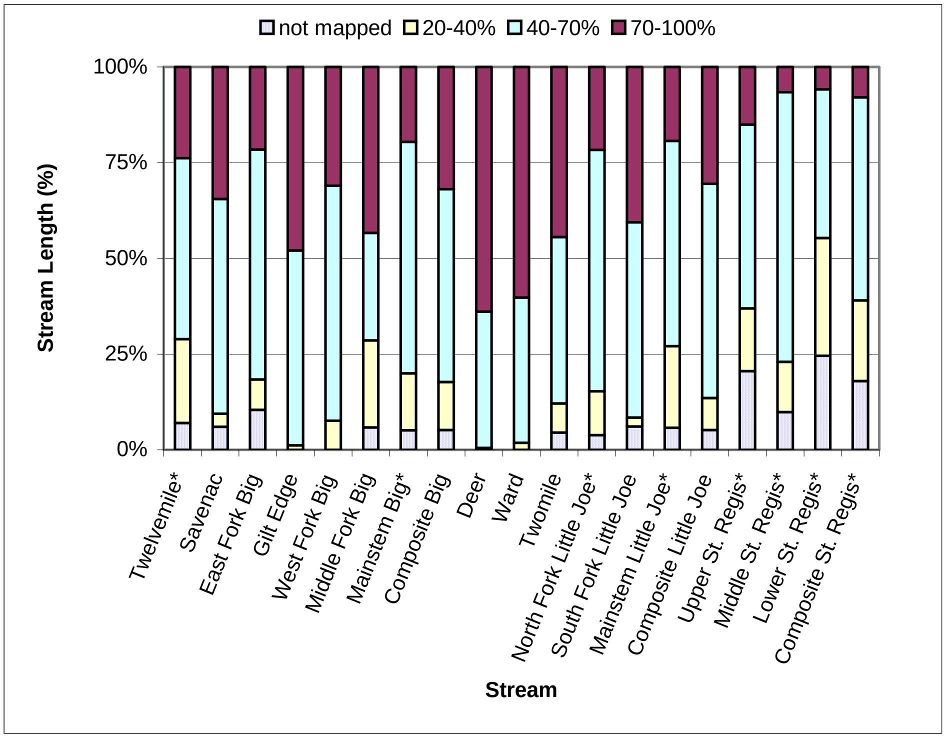

Figure M-2. Percent canopy cover for streams in St. Regis watershed

Table M-3. Percent canopy cover for stream reaches in the St. Regis watershed

Stream/Reach	Percent Canopy Cover			
	Not Mapped	20-40%	40-70%	70-100%
Twelvemile Creek*				
	7	22	47	24
Savenac Creek				
	6	3	56	35
Big Creek*				
Composite	5	12	50	32
East Fork	10	8	60	22
Gilt Edge	0	1	51	48
West Fork	0	8	61	31
Middle Fork	6	23	28	43
Mainstem*	5	15	61	20
Deer Creek				
	0	1	36	64
WardCreek				
	0	2	38	60
Twomile Creek				
	5	8	43	44
Little Joe Creek				
Composite	5	8	56	30
North Fork*	4	11	63	22
South Fork	6	2	51	41
Mainstem*	6	21	54	19

Table M-3. Percent canopy cover for stream reaches in the St. Regis watershed

Stream/Reach	Percent Canopy Cover			
	Not Mapped	20-40%	40-70%	70-100%
St. Regis*				
Composite	18	21	53	8
Upper	21	16	48	15
Middle	10	13	70	7
Lower	25	31	39	6

*Streams on 2006 303(d) list.

Air Photo Interpretation

None of the tributary stream reaches examined are without some type of channel alteration and/or bank riprap. Length of channel affected ranges from 0.78 miles in Twelvemile Creek, followed by 0.44 miles of Big Creek, to between 0.02 and 0.05 miles for the other reaches examined. Most of the riprap sections observed are associated with road encroachment (**Table M-4**).

Table M-4. Length of riprapped bank and altered channel (feet)

HUC 6 Tributary		Non-FS	FS	Total
Twelvemile Creek				
	Rip Rap	567		567
	Channel Alteration	2752	815	3567
	Total	3319	815	4134
Big Creek Mainstem				
	Rip Rap	1540	410	1950
	Channel Alteration	265	90	355
	Total	1805	500	2305
East Fork Big Creek				
	Rip Rap		80	80
	Channel Alteration		40	40
	Total		120	120
Middle Fork Big Creek				
	Rip Rap		70	70
	Channel Alteration		95	95
	Total		165	165
West Fork Big Creek				
	Rip Rap		200	200
	Channel Alteration		200	200
	Total		200*	200*
Little Joe Creek				
	Rip Rap		236	236
	Channel Alteration			
	Total		236	236
South Fork Little Joe Creek				
	Rip Rap		173	173
	Channel Alteration		1169+	1169+

Table M-4. Length of riprapped bank and altered channel (feet)

HUC 6 Tributary		Non-FS	FS	Total
	Total		1342	1342
North Fork Little Joe Creek				
	Rip Rap		180	180
	Channel Alteration			
	Total		180	180
Savenac Creek				
	Rip Rap	168	2100	2268
	Channel Alteration		3352	3352
	Total	168	5452	5620
Twomile Creek				
	Rip Rap			
	Channel Alteration		500	500
	Total		500	500

*Single stretch of 200 feet has been both rip rapped and altered. +Little Joe Slide

Field Measurements

Measured differences between bed elevation of cut off meanders and bed elevation of adjacent St. Regis River segments suggest that six to eight feet of channel incision has occurred. This drop in bed elevation is likely the result of increased stream power due to channel shortening and straightening (**Table M-5**).

Table M-5. Difference between cutoff meander bed elevation and St. Regis River bed elevation

Site	Elevation Difference (feet)
1	7.93
2	7.35
3	6.46

The feasibility study by Land & Water Consulting, Inc. (1996) found incision of the current channel bed ranging from 4-5 feet to 6-12 feet below the elevation of adjacent cutoff meanders. The reach of stream studied was shortened from the original meander pattern to the current straightened channel by approximately 1500 feet, or about 25%.

Discussion

Analyses of stream alterations including channelization, riprap and encroachment by roads using three methods described above, GIS analysis, air photo interpretation and field measurements, support the listing of the St. Regis River and many of its tributaries as 303(d) listed streams. This study found:

- One third of all stream length in the St. Regis River watershed is within sediment contributing distance of roads.
- 15% of stream length has diminished ability to recruit large woody debris because of road proximity.

- Almost all of the St. Regis watershed and its tributary watersheds have a High (1.7-4.7 mi/mi2) road density, and therefore, very likely a diminished ability to support strong populations of key salmonids, the ability to support the Beneficial Use of cold water trout fishery.
- All major tributary stream reaches examined have some length of altered channel and/or riprapped stream bank. Twelvemile Creek and Big Creek have the greatest length of channel/bank altered and/or riprapped bank, with 0.78 and 0.44 miles respectively.
- Current elevation of St. Regis River bed in some sections is 4 -12 feet lower than the bed elevation of the St. Regis River in its meander pattern prior to meander cutoff and channel confinement by transportation development.

Many of these findings are consistent with the identification of habitat and sediment related impairment conditions in this drainage. The location of roads relative to streams and the overall length of riprapped bank and altered channel appear to be good indicators of impairment conditions/lack of beneficial use support. Streams with the least amount of riparian canopy cover, with the greatest extent of channel alterations, and with the largest percent of stream length with a road within 125 feet tend to be impaired. Roads near streams contribute to the loss of canopy cover and overall stream protection, and often promote the need for channel alterations to protect transportation infrastructure. Road density is another factor often considered to be a good indicator of impairment conditions. In the St. Regis watershed however, this does not appear to be the case. For example, Deer Creek, Ward Creek, and lower Savenac Creek have relatively high road densities, but all are identified as supporting water quality standards. It appears that streams in the St. Regis watershed with healthy, mature riparian cover, lack of road encroachment, and few or no channel alterations, are less susceptible to some of the impacts associated with road density.

Water quality planning and TMDL development must account for the impacts roads have on impaired streams. These impacts include increased erosion and transport capacity of the stream as a result of road-related near-stream alterations and other alterations. For example, gross changes in the hydrology of the St. Regis River as a result of confinement, shortening, straightening, and armoring, have increased overall stream gradient and increased its competence and capacity, causing down cutting, incision, and a lowering of the base level. While increased stream capacity has caused accelerated bank erosion in some locations, many other locations have been armored so that sediment supply from natural bank erosion has been eliminated.

Unfortunately, some of the impacts from roads cannot be easily mitigated or the causing factors cannot be significantly removed or reduced (as with the Interstate Highway). Also, road BMP's typically designed to reduce sediment inputs from the surface and cut/fill slopes of roads are not generally adequate to mitigate the types of impacts associated with encroachment and overall confinement caused by roads. Rerouting or total closure of an encroaching road or road segment is one option that can be considered to resolve some of the encroachment impacts from roads, but such efforts may not be practical in all cases.

Literature Cited

Belt G. H., J. O' Laughlin and T. Merrill. 1992. Design of Forest Riparian Buffer Strips for the Protection of Water Quality: Analysis of Scientific Literature. Idaho Forest, Wildlife and Range Policy Analysis Group, Report No.8, Idaho Forest, Wildlife, and Range Experiment Station, University of Idaho.

Hendrickson, S. and K. Cikanek. 2000. Middle Clark Fork River Section 7 Consultation Watershed Baseline Analysis. Lolo National Forest.

Land & Water Consulting, Inc.. 1996. St. Regis River Restoration: Channel relocation feasibility and design. Prepared for Lolo National Forest. February 12, 1996.

Mullan, Captain John. 1863. Report on the Construction of a Military Road from Fort Walla Walla to Fort Benton. Ye Galleon Press; Fairfield , Washington. Washington GPO.

USDA Forest Service. 1995. Inland Native Fish Strategy, Environmental Assessment. Decision Notice and Finding of No Significant Impact.

USDA, Forest Service. 1996. Integrated Scientific Assessment for Ecosystem Management In The Interior Columbia Basin And Portions Of The Klamath And Great Basins. GTR PNW-GTR-382.

Wemple, B.C. and J.A. Jones. 2003. Runoff production on forest roads in a steep, mountain catchment. Water Resources Research 39(8), 1220, doi:10.1029/2002WR001744, 2003.